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Experimental and theoretical studies of cylindrical Hall thrusters[1]

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The Hall thruster is a mature electric propulsion device that holds considerable promise in terms of the propellant saving potential. The annular design of the conventional Hall thruster, however, does not naturally scale to low power. The efficiency tends to be lower, and the lifetime issues are more aggravated. Cylindrical geometry Hall thrusters have lower surface-to-volume ratio than conventional thrusters and, thus, seem to be more promising for scaling down [Y. Raitses and N.J. Fisch, *Phys. Plasmas* **8**, 2579 (2001)]. The cylindrical Hall thruster (CHT) is fundamentally different from the conventional design in the way the electrons are confined and the ion space charge is neutralized. Both the large (9 cm channel diam., 600 – 1000 W) and miniaturized (2.6 cm channel diam., 50 – 300 W) CHTs exhibit performances comparable with those of the state-of-the-art conventional (annular) design Hall thrusters of similar sizes [A. Smirnov *et al.*, *J. Appl. Phys.* **92**, 5673 (2002)]. A comprehensive experimental and theoretical study of the CHT physics has been conducted, addressing the questions of electron cross-field transport, propellant ionization, plasma-wall interaction, and formation of the electron distribution function. Probe measurements in the harsh plasma environment of the micro thruster were performed. Several interesting effects, such as the unusually high ionization efficiency and enhanced electron transport, were observed [A. Smirnov *et al.*, *IEEE Trans. on Plasm. Sci.* **34**, 132 (2006)]. Kinetic simulations suggest the existence of the strong fluctuation-enhanced electron diffusion and predict the non-Maxwellian shape of the electron distribution function [A. Smirnov *et al.*, *Phys. Plasmas* **11**, 4922 (2004)]. Through the acquired understanding of the new physics, ways for further optimization of this means for low-power space propulsion are suggested. Substantial flexibility in the magnetic field configuration of the CHT is the key tool in achieving the high-efficiency operation.

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